BELCO RESEARCH LABORATORIES

INTERIM REPORT NO. 6

MINIATURIZED HIGH-EFFICIENCY

R-F FILTERS

Contract No. AF 33(600)-22861

49-53 Edison Place Newark, New Jersey

INTERIM ENGINEERING REPORT NO. 6

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For the Period 29 March 1954 to 29 June 1954

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Newark 2, New Jersey

Contract No. AF 33(600)-22861
E. O. No. R-112-19 SR-66%

27 August 1954

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FOREWORD

This is the sixth interim report submitted under Contract No. AF 33(600)-22861, Expenditure Order No. R-112-19 SR-662, Miniaturized High-Efficiency R-F Filters.

The program is being directed by Mr. C. B. Winston of Wright Air Development Center, Directorate of Laboratories, Components and Systems Laboratory. The work covered by this report was performed under the direct supervision of Mr. Necdet Ergul, Project Engineer at Balco Research Laboratories and Dr. Seymour Edelburg, Head of the Electronics Division.

ABSTRACT

This report contains a discussion of investigations being conducted on r-f filters and their components. This period is primarily a construction period accompanied by experimentation with some theoretical investigations of certain phases of the work. The results of the investigations are also presented.

We are investigating which type of filter design is to be used in constructing the low-pass filter with a cutoff frequency of 30 mc. The best type of filter design for the low-pass 1500 - mc filter is also being investigated with emphasis on both electrical performance and physical compactness.

Low-pass filters with cutoff frequencies at 190 mc, 275 mc and 400 mc are under construction. Construction of the final miniaturized model of the high-pass 2600-mc filter has been completed.

With respect to the variable-f_c filters, a new approach to the shielding problems has been found which appears to have interesting possibilities. Ways of varying the impedances are now being investigated.

PURPOSE

The purpose of this program is the development of a series of miniaturized, high-efficiency, r-f filters to be used in conjunction with the antennas of various receivers and transmitters for suppression of spurious radiations and harmonics. In particular, the following units are to be designed and constructed.

TYPE OF FILTER	CUTOFF FREQUENCY (mc)
High Pass	1.8
Low Pass	30
High Pass	200
Low Pass	400
High Pass	210
Low Pass	275
High Pass	2600
High Pass	145
Low Pass	190
High Pass	400
High Pass	340
Low Pass	1500

Performance goals for these units are as follows: a maximum insertion loss of 2 db in the pass band; a minimum attenuation of 50 db in the stop band, and physical size to be held to a minimum. Detail requirements

including power rating and impedance are set forth in Exhibit WCES 52-49 dated 27 May 1952.

During the sixth quarterly period, development work was continued according to the general procedures outlined in the Fifth Interim Report. In particular, the work included: (1) construction of experimental models of filters with cutoff frequencies of 1.8 mc and 30 mc; (2) construction of low-pass filters with cutoff frequencies from 100 mc to 400 mc; (3) final testing of the high-pass 2600-mc filter; (4) design and experimentation for the low-pass, 1500-mc filter; (5) continued theorerical and experimental investigation of variable f_c filters.

HIGH-PASS 1.8-MC FILTER

The miniature high-temperature capacitors under order have been delivered and an experimental model using these components and specially constructed miniature inductors wound on powdered iron toroids, has been built. The attenuation characteristics of this unit are shown in figure 1.

This experimental model will now be miniaturized and the miniaturized unit constructed inside a tube with an outside diameter of 1 1/4 inches and an overall length of less than seven inches. The performance of the miniaturized unit at high temperature is expected to be very close

to its performance at room temperature. Results of high-temperature performance tests now being made will be reported in our next monthly letter.

LOW-PASS 30-MC FILTER

Transmission line filters with cutoff frequencies in the 30-mc region, although efficient, became rather large and bulky in overall physical dimensions. For this reason a design using lumped parameters would be preferable if satisfactory filter performance can be maintained. An experimental model using lumped parameters had been previously been constructed, as reported. Its performance was found to be satisfactory, and the unit was considered to merit miniaturization. We have therefore begun constructional details for a miniaturized final model, which will then be tested under high and low temperature conditions.

LOW-PASS FILTERS WITH F_c FROM 190 MC TO 400 MC

Low-pass filters with cutoff frequencies at 190 mc, 275 mc and 400 mc are under construction. During the past period, some weak points in the mechanical design have been corrected, special consideration being given to compactness and ruggedness of the units.

One serious mechanical design consideration has been to incorporate into the units preventive and compensative measures to overcome the relative differences of expansion of its various parts at high temperatures. The units have been so designed that their operation is not much affected at 200°C. It is estimated that the cutoff frequency will shift only a few percent at that temperature. The performance of this filter at high temperature is now being investigated.

HIGH-PASS 2600-MC FILTER

Construction of the final miniaturized model has been completed. The unit is now being tested at both high and low temperatures.

LOW-PASS 1500-MC FILTER

Filters with cutoff frequencies below 500 mc and those with cutoff frequencies above 2000 mc show fundamental differences of design. Since the 1500-mc cutoff filters fall between those two catagories, we are investigating the advantages of both types of design before making our choice.

We have constructed a unit using transmission lines and lumped parameters, which will be tested at 200°C. A design incorporating transmission line sections with discontinuities is also being investigated. The

final decision on design will depend on results obtained from our investigations. Both optimum performance and physical compactness will be considered.

VARIABLE-F_c FILTERS

Most of our efforts have been concentrated on improving the transmission-line series arms of the filter. As mentioned in our previous reports, difficulties have been encountered due to the radiation of the transmission lines. During the past month, this has been eliminated by using a different approach to the shielding problem. Except for a 5-db hump (no wider than 8% of the total pass band) before cutoff, the new attenuation characteristics curve adhered very closely to that predicted by theory. The insertion loss was low, for the most part under 1 db; the attenuation of the stop band was measured up to three times the cutoff frequency and was found to be over 60 dbs. Furthermore, the rise from cutoff to 60-db attenuation was within 10 percent.

Later experimentation revealed that the hump in the curve near cutoff was caused by incorrect series arm impedances and could be eliminated by careful adjustment.

Since this new approach showed such great possibilities, a practical way of varying the impedances will be studied and an attempt made to construct a working model.

CONCLUSIONS

There are several distinct types of filter design which together cover the frequency range of the exhibit. These types of design have been investigated and experimental models have been built.

The remainder of the program calls for the construction of final models of some of these types as samples for the exhibit. All units are being carefully constructed and ruggedized to meet the environmental conditions. The building phase will be accompanied by necessary experimentation.

PROGRAM FOR THE NEXT INTERVAL

1. Representative models of high-pass and low-pass filters will be built and tested at 200 degrees Centigrade. One model will be of the all lumped-parameter type, one of the distributed parameter type and one of the combined lumped and distributive types. Results of the tests will be reported in our monthly reports.

2. Work will be continued on miniaturizing into final form the high-pass filters up to 400 mc.

3. With respect to the variable-f_c filters, further theoretical and experimental work will be done on the shielded series arm configuration.

Approved by: Seymour Edelberg

Seymour Edelberg, Head, Electronics Div.

Prepared by: Necdet Ergul

Necdet Ergul, Project Engineer

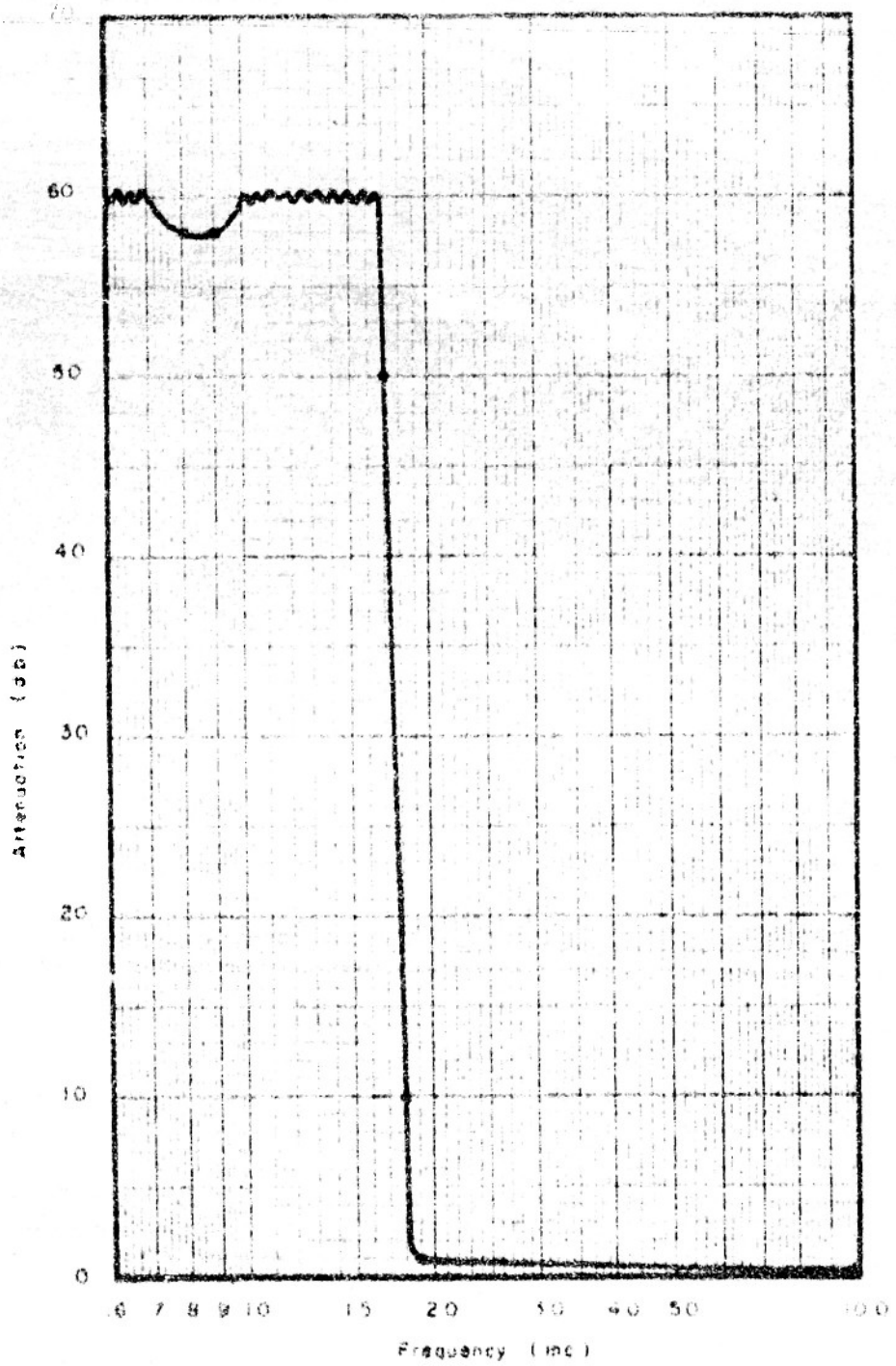

Figure 1

Attenuation Characteristics of Unminiaturized High-Pass Filter

Cutoff Frequency: 8 mc

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